

WHAT IS CLAIMED IS:

1. A semiconductor element comprising:
5 a field-effect transistor including a source electrode provided on a first surface side of a semiconductor body, a drain electrode provided on a second surface side opposite to the first surface side, a first conductivity type semiconductor that includes a first conductivity type drift region and is included in the semiconductor body, and a second conductivity type semiconductor included in the semiconductor body; and
10 a Schottky diode formed by contact between the first conductivity type semiconductor and a metal electrode,
wherein the field-effect transistor and the Schottky diode are arranged such that a first depletion layer stemming from the Schottky diode is superimposed on a second depletion layer spreading around the second
15 conductivity type semiconductor in an off-state of the field-effect transistor.
2. The semiconductor element according to claim 1, wherein the semiconductor body includes a region for a group of transistors in which a plurality of the field-effect transistors are formed, and the field-effect
20 transistors are insulated field-effect transistors,
each of the insulated gate field-effect transistors further comprising:
a first conductivity type source region formed in the second conductivity type semiconductor, and a gate electrode provided on an insulating film formed on the first surface side,
25 wherein in each of the insulated gate field-effect transistors, the second conductivity type semiconductor is provided on the first surface side; and
the source electrode is provided so as to be in contact with the second conductivity type semiconductor and the source region,
30 wherein the Schottky diode is included in the region for a group of transistors and is formed by contact between the drift region exposed between the transistors on the first surface side and the metal electrode.
3. The semiconductor element according to claim 1, wherein the
35 semiconductor body includes a region for a group of transistors in which a plurality of the field-effect transistors are formed, and the field-effect transistors are insulated field-effect transistors,

each of the insulated gate field-effect transistors further comprising:
a first conductivity type source region formed in the second
conductivity type semiconductor, a recess that penetrates the source region
and the second conductivity type semiconductor to reach the first
5 conductivity type drift region, and a gate electrode on an insulating film
formed in the recess,

wherein in each of the insulated gate field-effect transistors,
the second conductivity type semiconductor is provided on the first
surface side; and

10 the source electrode is provided so as to be in contact with the second
conductivity type semiconductor and the source region;

wherein the Schottky diode is included in the region for a group of
transistors and is formed by contact between the drift region exposed
between the transistors on the first surface side and the metal electrode.

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4. The semiconductor element according to claim 1, wherein the field-effect
transistor is an insulated gate field-effect transistor,

the insulated gate field-effect transistor further comprising:

20 a first conductivity type source region formed in the second
conductivity type semiconductor, a recess that penetrates the source region
and the second conductivity type semiconductor to reach the first
conductivity type drift region, and a gate electrode on the insulating film
formed in the recess,

25 wherein in the insulated gate field-effect transistors,
the second conductivity type semiconductor is provided on the first
surface side; and

the source electrode is provided so as to be in contact with the second
conductivity type semiconductor and the source region,

30 wherein the Schottky diode is formed by contact between the drift
region in contact with the recess and the metal electrode.

5. The semiconductor element according to claim 1, wherein the field-effect
transistor is a junction field-effect transistor,

the junction field-effect transistor further comprising:

35 a first conductivity type source region on the first surface side, and a
gate electrode,

wherein in the junction field-effect transistor,

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the source electrode is provided so as to be in contact with the source region; and

the gate electrode is provided so as to be in contact with the second conductivity type semiconductor,

5 wherein the Schottky diode is formed by contact between the first conductivity type drift region exposed on the first surface side and the metal electrode.

6. The semiconductor element according to claim 1, wherein the
10 semiconductor body is made of silicon carbide.

7. The semiconductor element according to claim 6, wherein the silicon
15 carbide is obtained by causing epitaxial growth on a surface of a silicon carbide substrate that is either one of the following I and II to form a silicon carbide layer:

I. (111) Si plane of β -SiC, (0001) Si plane of 6H or 4H-SiC, or Si plane of
15R-SiC, or offcut planes within 10 degrees of these Si planes; and

II. (100) plane of β -SiC, (110) plane of β -SiC, (1-100) plane of 6H or 4H-SiC,
20 (11-20) plane of 6H or 4H-SiC, or offcut planes within 15 degrees of these planes.

8. A semiconductor element comprising:

25 a field-effect transistor including a source electrode provided on a first surface side of a semiconductor body, a drain electrode provided on a second surface side opposite to the first surface side, a first conductivity type semiconductor that includes a first conductivity type drift region and is included in the semiconductor body, and a second conductivity type semiconductor included in the semiconductor body; and

30 a Schottky diode formed by contact between the first conductivity type semiconductor and a metal electrode,

wherein the field-effect transistor and the Schottky diode are arranged closely so that a second conductivity type semiconductor other than said second conductivity type semiconductor is not interposed between the field effect transistor and the Schottky diode.

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9. The semiconductor element according to claim 8, wherein the semiconductor body includes a region for a group of transistors in which a

plurality of the field-effect transistors are formed, and the field-effect transistors are insulated field-effect transistors,

each of the insulated gate field-effect transistors further comprising:
a first conductivity type source region formed in the second

5 conductivity type semiconductor, and a gate electrode provided on an insulating film formed on the first surface side,

wherein in each of the insulated gate field-effect transistors,
the second conductivity type semiconductor is provided on the first surface side; and

10 the source electrode is provided so as to be in contact with the second conductivity type semiconductor and the source region,

wherein the Schottky diode is included in the region for a group of transistors and is formed by contact between the drift region exposed between the transistors on the first surface side and the metal electrode.

15 10. The semiconductor element according to claim 8, wherein the semiconductor body includes a region for a group of transistors in which a plurality of the field-effect transistors are formed, and the field-effect transistors are insulated field-effect transistors,

20 each of the insulated gate field-effect transistors further comprising:
a first conductivity type source region formed in the second

conductivity type semiconductor, a recess that penetrates the source region and the second conductivity type semiconductor to reach the first conductivity type drift region, and a gate electrode on an insulating film
25 formed in the recess,

wherein in each of the insulated gate field-effect transistors,
the second conductivity type semiconductor is provided on the first surface side; and

30 the source electrode is provided so as to be in contact with the second conductivity type semiconductor and the source region;

wherein the Schottky diode is included in the region for a group of transistors and is formed by contact between the drift region exposed between the transistors on the first surface side and the metal electrode.

35 11. The semiconductor element according to claim 8, wherein the field-effect transistor is an insulated gate field-effect transistor,
the insulated gate field-effect transistor further comprising:

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a first conductivity type source region formed in the second conductivity type semiconductor, a recess that penetrates the source region and the second conductivity type semiconductor to reach the first conductivity type drift region, and a gate electrode on the insulating film
5 formed in the recess,

wherein in the insulated gate field-effect transistors,

the second conductivity type semiconductor is provided on the first surface side; and

10 the source electrode is provided so as to be in contact with the second conductivity type semiconductor and the source region,

wherein the Schottky diode is formed by contact between the drift region in contact with the recess and the metal electrode.

12. The semiconductor element according to claim 8, wherein the field-effect transistor is a junction field-effect transistor,

the junction field-effect transistor further comprising:

a first conductivity type source region on the first surface side, and a gate electrode,

wherein in the junction field-effect transistor,

20 the source electrode is provided so as to be in contact with the source region; and

the gate electrode is provided so as to be in contact with the second conductivity type semiconductor,

25 wherein the Schottky diode is formed by contact between the first conductivity type drift region exposed on the first surface side and the metal electrode.

13. The semiconductor element according to claim 8, wherein the semiconductor body is made of silicon carbide.

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14. The semiconductor element according to claim 8, wherein the silicon carbide is obtained by causing epitaxial growth on a surface of a silicon carbide substrate that is either one of the following I and II to form a silicon carbide layer:

35 I. (111) Si plane of β -SiC, (0001) Si plane of 6H or 4H-SiC, or Si plane of 15R-SiC, or offcut planes within 10 degrees of these Si planes; and

II. (100) plane of β -SiC, (110) plane of β -SiC, (1-100) plane of 6H or 4H-SiC,

(11-20) plane of 6H or 4H-SiC, or offcut planes within 15 degrees of these planes.

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